First Semester Examination
2019/2020 Academic Session

December 2019 / January 2020

EAS153 – Civil Engineering Materials
(*Bahan Kejuruteraan Awam*)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **SEVENTEEN (17)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH BELAS (17)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

***Instructions**: This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.*

***[Arahan**: Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

(1). (a). The construction of a massive foundation for a high-rise building requires the cement to have low heat evolution characteristic and highly resistant to sulphate. Suggest a suitable EN 197 cement that will suit the intended application. Discuss extensively the main characteristics of the cement which make it suitable for concreting the mass concrete foundation and at the same time sufficiently resistant to sulphate environment.

Pembinaan asas yang besar untuk satu bangunan tinggi memerlukan penggunaan simen yang mempunyai ciri pembebasan haba yang rendah dan rintangan yang tinggi terhadap sulfat. Cadangkan simen EN 197 yang sesuai untuk aplikasi yang dirancang. Bincangkan secara ekstensif ciri-ciri simen berkenaan yang menjadikanya sesuai untuk pengkonkritan asas konkrit yang besar dan pada masa yang sama tahan terhadap persekitaran bersulfat.

[10 marks/*markah*]

(b). The oxide compositions of a type of Portland cement are given in **Table 1**. Determine the major compound compositions. Discuss the probable strength development and heat evolution characteristics of the cement, as well as comment the suitability of the cement for sulphate exposure environment. Use the given Bouge's equations.

*Komposisi oksida untuk satu jenis simen Portland diberikan di dalam **Jadual 1**. Tentukan komposisi sebatian utama. Bincangkan kemungkinan ciri-ciri pembentukan kekuatan dan pembebasan haba simen berkenaan, serta komen kesesuaian simen untuk pendedahan persekitaran bersulfat. Gunakan persamaan Bouge yang diberikan.*

[10 marks/*markah*]

Table 1: Oxide compositions of a Portland cement
*(**Jadual 1:** Komposisi oksida untuk simen Portland)*

Oxide Compositions, (%)	
CaO	62.5
SiO_2	25.5
Al_2O_3	4
Fe_2O_3	4.3
MgO	0.5
SO_3	1
K_2O, Na_2O}	0.5
Insoluble residue	0.4
Loss on ignition	0.8
Others	0.5

$C_3S = 4.07(CaO) – 7.60(SiO_2) – 6.72(Al_2O_3) – 1.43(Fe_2O_3) – 2.85(SO_3)$
$C_2S = 2.87(SiO_2) – 0.754(3CaO.SiO_2)$
$C_3A = 2.65(Al_2O_3) – 1.69(Fe_2O_3)$
$C_4AF = 3.04(Fe_2O_3)$

(2). (a). Using appropriate sketches, briefly describe the **FOUR (4)** probable moisture conditions of an aggregate.

*Menggunakan lakaran yang sesuai, jelaskan secara ringkas **EMPAT (4)** keadaan lembapan yang mungkin untuk sesuatu agregat.*

[4 marks/*markah*]

(b). Explain briefly how the toughness of coarse aggregate sample is determined based on the aggregate impact value test.

Terangkan secara ringkas bagaimana ketahanan sampel agregat kasar ditentukan berdasarkan ujian nilai hentaman agregat.

[4 marks/*markah*]

(c). **Table 2** gives the grading of two samples of sand in term of weight retained on the relevant sieves. Determine the fineness modulus for each sand sample. Based on the fineness modulus values, explain which sand will require greater water content when used in concrete, assuming the quantity and characteristics of other materials used being the same.

Jadual 2 *menunjukkan penggredan dua sampel pasir dalam bentuk berat tertahan pada ayak-ayak yang berkaitan. Tentukan modulus kehalusan untuk setiap sampel pasir. Berdasarkan nilai modulus kehalusan, terangkan pasir yang mana akan memerlukan kandungan air yang tinggi bila digunakan di dalam konkrit, dengan anggapan kandungan dan ciri-ciri bahan yang lain adalah sama.*

Table 2: Grading of Sand
Jadual 2: *Penggredan Pasir*

Sieve Size /*Saiz Ayak*	Weight Retained/*Berat Tertahan* (g)	
	Sand A/*Pasir A*	Sand B/*Pasir B*
10 mm	0	0
5 mm	0	0
2.36 mm	80	0
1.18 mm	146	8.6
600 µm	115	16.1
300 µm	81.1	280.1
150 µm	68.8	185.3
Pan	9.1	9.9
Total	500	500

[12 marks/*markah*]

(3). (a). Explain the term “pozzolan”.

Terangkan terminologi “pozzolan”.

[4 marks/*markah*]

(b). A concrete mix has been proportioned to achieve workability of 100 mm (slump value) and a 28-day compressive strength of 40 MPa. Several trial mixes performed portray that the concrete mix consistently achieved lower slump value than the stipulated workability but complied with the strength requirement. If the proportion of the concrete will not be changed, suggest a suitable chemical admixture that could be used to increase the workability of the concrete mix without increasing the water content. Explain how the admixture work and improve the workability of the concrete.

Satu campuran konkrit telah disediakan untuk mencapai kebolehkerjaan 100 mm (nilai penurunan) dan kekuatan mampatan 28-hari 40 MPa. Beberapa campuran cubaan yang telah dilakukan mempamerkan bahawa campuran konkrit memberikan kebolehkerjaan yang rendah daripada nilai yang ditetapkan tetapi mematuhi keperluan kekuatan. Sekiranya nisbah campuran konkrit tidak akan diubah, cadangkan bahan tambah kimia yang sesuai untuk meningkatkan kebolehkerjaan konkrit tanpa menambah kandungan air. Terangkan bagaimana bahan tambah ini berfungsi dan meningkatkan kebolehkerjaan konkrit berkenaan.

[6 marks/*markah*]

(c). Discuss the influence of quantity of mixing water on workability, strength and durability performance of concrete.

Bincangkan pengaruh kuantiti air bancuhan terhadap kebolehkerjaan, kekuatan dan prestasi ketahanlasakan konkrit.

[10 marks/*markah*]

(4). Using the guideline on “Design of Normal Concrete Mixes” (BRE Report, 1988 given in Appendix) and based on the given data, determine the quantity of materials for a trial mix of 0.05 m^3, assuming that the aggregates are in saturated and surface dry condition. If both the river sand and granite have moisture content of 1.00% and 0.75%, respectively, determine the mix proportions for 1 m^3 and for the trial mix of 0.05 m^3. Use the attached mix design forms and **include the attachment used with your answer script.**

*Menggunakan garis panduan mengenai "Rekabentuk Campuran untuk Konkrit Biasa" (BRE Report, 1988 yang diberikan dalam Lampiran) dan berdasarkan data yang diberikan, tentukan kuantiti bahan-bahan untuk satu campuran cubaan 0.05 m^3, dengan menganggapkan bahawa agregat berada dalam keadaan permukaan kering dan tepu. Jika kedua-dua pasir sungai dan granit masing-masing mempunyai kandungan lembapan 1.00% dan 0.75%, tentukan kuantiti bahan untuk 1 m^3 dan juga campuran cubaan 0.05 m^3. Gunakan jadual rekabentuk campuran yang dilampirkan dan **sertakan lampiran yang digunakan bersama kertas jawapan anda.***

Characteristic strength: 30 MPa at 28 days
(Kekuatan ciri: 30 MPa pada 28 hari)

Specified margin: 5 MPa
(Jidar yang ditetapkan: 5 MPa)

Cement type: Ordinary Portland cement
(Jenis simen: Simen Portland biasa)

Aggregate type (coarse): Granite; Aggregate type (fine): River sand
(Jenis agregat kasar: Granit; Jenis agregat halus: Pasir sungai)

Maximum free water/cement ratio: 0.50
(Nisbah air/simen maksima: 0.50)

Slump: 90 mm
(Penurunan: 90 mm)

Maximum aggregate size: 20 mm
(Saiz maksima agregat: 20 mm)

Relative density of aggregate (SSD): 2.7
(Ketumpatan relatif agregat (SSD): 2.7)

Percentage passing 600 μm sieve: 60 %
(Peratusan melepasi ayak 600 μm: 60 %)

[20 marks/*markah*]

(5). In construction, low carbon steel, medium carbon steel and high carbon steel are commonly used building materials. Their properties can be controlled as well as changed by various heat treatments.

Dalam pembinaan, keluli karbon rendah, keluli karbon sederhana dan keluli karbon tinggi merupakan bahan binaan yang biasa digunakan. Ciri-cirinya boleh dikawal dan juga diubah menggunakan rawatan haba dengan suhu yang pelbagai.

(a). Explain the differences between low carbon steel, medium carbon steel and high carbon steel.

Terangkan perbezaan antara keluli karbon rendah, keluli karbon sederhana dan keluli karbon tinggi.

[9 marks/*markah*]

(b). Explain **THREE (3)** types of heat treatment processes for the steel.

*Terangkan **TIGA (3)** jenis rawatan haba untuk keluli.*

[6 marks/*markah*]

(c). **Table 3** shows the data of applied force against elongation of a steel sample from a laboratory test. Plot a graph and calculate the ultimate stress. The area of steel is 68.34 mm^2. Include all the phases of elastic and plastic regions.

Jadual 3 *menunjukkan data daya yang dikenakan melawan pemanjangan untuk satu sampel keluli daripada satu ujian makmal. Plotkan graf dan kirakan tegasan muktamad. Saiz keluli adalah 68.34 mm^2. Tunjukkan semua fasa kawasan elastik dan plastik.*

Table 3: Force vs Elongation
Jadual 3: *Daya vs Pemanjangan*

	Force (kN) *Daya (kN)*	Elongation (mm) *Pemanjangan (mm)*
1	0.0000	0.0000
2	9.0201	1.1050
3	27.0312	4.1115
4	38.0706	5.1327
5	39.4665	6.6910
6	38.4348	7.2118
7	38.2635	7.7658
8	39.3228	26.6113
9	43.6631	38.0884
10	45.9920	51.0802
11	26.0329	57.3295

[5 marks/*markah*]

(6). (a). Fired clay brick manufacturing process was designed to ensure the product has a high engineering quality. The firing process also known as sintering process is the critical process to obtain dense fired clay brick.

Proses pembuatan bata tanah liat bakar direkabentuk bagi memastikan produk mempunyai kualiti kejuruteraan yang tinggi. Proses pembakaran juga dikenali sebagai proses pensinteran merupakan proses yang kritikal bagi mendapatkan bata tanah liat bakar yang padat.

(i) Describe the manufacturing process of making fired clay brick by using a suitable flowchart.

Terangkan proses pembuatan bata tanah liat bakar menggunakan carta alir yang bersesuaian.

[3 marks/*markah*]

(ii). Descrice **THREE (3)** main stages of fired clay brick firing process.

*Terangkan **TIGA (3)** fasa utama proses pembakaran bata tanah liat bakar.*

[6 marks/*markah*]

(iii). Determine the compressive strength of fired clay brick in **Table 4**.

*Tentukan nilai kekuatan mampatan bagi bata tanah liat bakar dalam **Jadual 4**.*

Table 4/*Jadual 4*

	Size/ *Saiz*	Maximum Load/ *Beban Maksimum*
Engineering Brick/ *Bata Kejuruteraan*	225x101.5x70 mm	855 kN

[1 marks/*markah*]

(b). Timber as a building material falls into two major classes which are natural and man-made. Based on Malaysian Standard MS544 Part 2, the natural timber is categorised into seven strength groups (SG1-SG7). Timber with high strength can carry heavy load and can be utilized as a structural member such as beam.

Kayu sebagai bahan binaan terbahagi dalam dua kategori utama iaitu semulajadi dan buatan manusia. Berdasarkan Malaysia Standard MS544 Bahagian 2, kayu semulajadi telah dikategorikan kepada tujuh kumpulan kekuatan (SG1-SG7). Kayu yang tinggi kekuatannya boleh menanggung beban berat dan boleh digunakan sebagai anggota struktur seperti rasuk.

(i). In your opinion, can light red meranti wood be used as a structural beam to support heavy load.

Pada pendapat anda, bolehkah kayu meranti merah muda digunakan sebagai struktur rasuk yang menyokong beban berat.

[1 marks/*markah*]

(ii). Explain **THREE (3)** types of defect and how each one affects the quality of timber.

*Terangkan **TIGA (3)** jenis kecacatan dan bagaimana setiap satu mempengaruhi kualiti kayu.*

[6 marks/*markah*]

(iii). Explain the following man-made timber product
Terangkan produk kayu buatan manusia yang berikut

(a). Particle Board
Papan Serpai

(b). Laminated Veneer Lumber
Kayu venir berlamina

(c). Cross Laminated Timber
Kayu berlamina silang

[3 marks/*markah*]

APPENDIX A/*LAMPIRAN A*
DOE CONCRETE MIX DESIGN

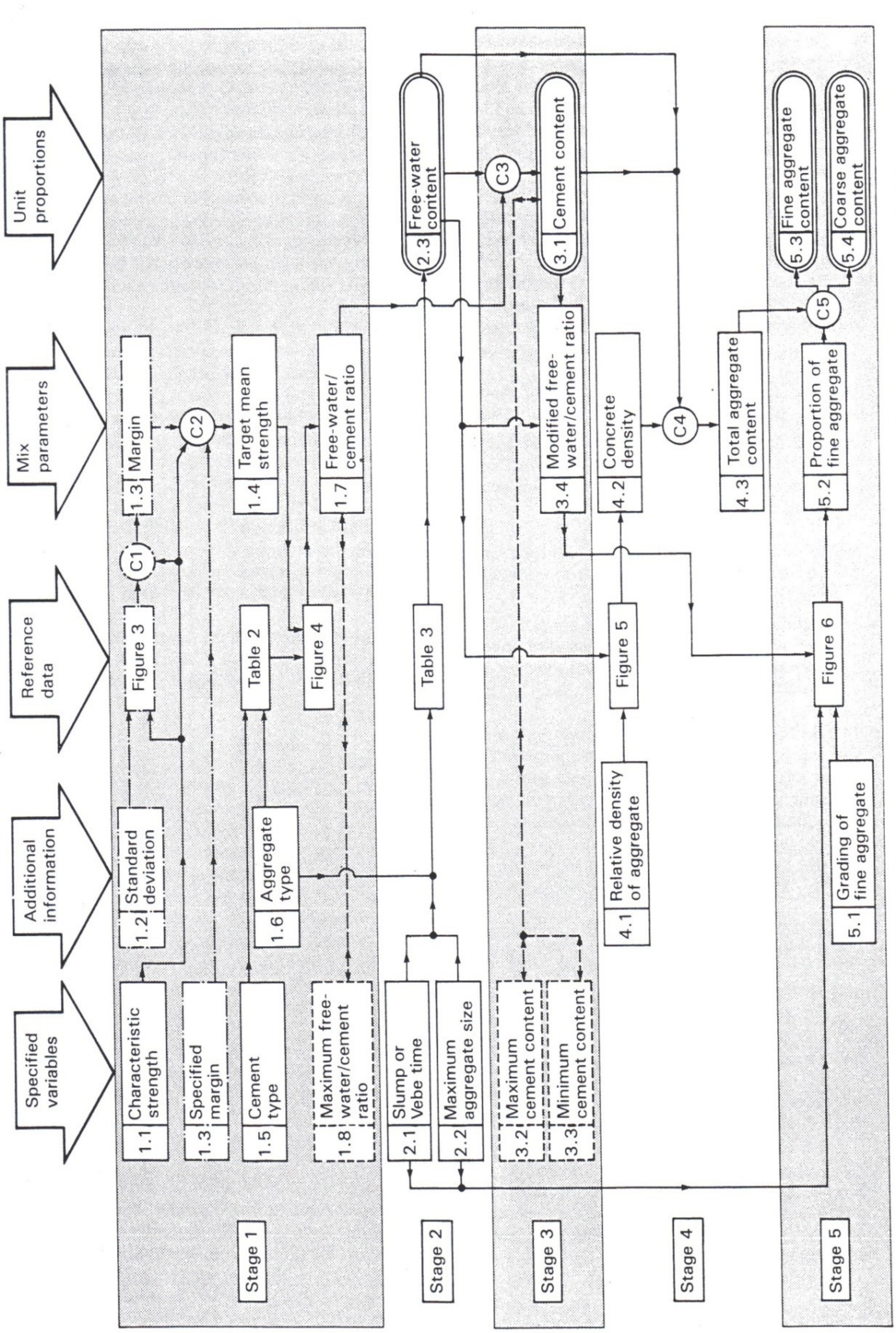

Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation
Items in chain-dotted boxes are alternatives

ANGKA GILIRAN/*INDEX NO*:____________

Concrete mix design form

Job title ....

Stage	Item		Reference or calculation	Values
1	1.1	Characteristic strength	Specified	____ N/mm² at ____ days Proportion defective ____ %
	1.2	Standard deviation	Fig 3	____ N/mm² or no data ____ N/mm²
	1.3	Margin	C1 or Specified	(k = ____) ____ × ____ = ____ N/mm² ____ N/mm²
	1.4	Target mean strength	C2	____ + ____ = ____ N/mm²
	1.5	Cement type	Specified	OPC/SRPC/RHPC
	1.6	Aggregate type: coarse Aggregate type: fine		Crushed/uncrushed Crushed/uncrushed
	1.7	Free-water/cement ratio	Table 2, Fig 4	____ } Use the lower value ____
	1.8	*Maximum free-water/cement ratio*	*Specified*	____ }
2	2.1	Slump or Vebe time	Specified	Slump ____ mm or Vebe time ____ s
	2.2	Maximum aggregate size	Specified	____ mm
	2.3	Free-water content	Table 3	____ kg/m³
3	3.1	Cement content	C3	____ ÷ ____ = ____ kg/m³
	3.2	*Maximum cement content*	*Specified*	____ kg/m³
	3.3	*Minimum cement content*	*Specified*	____ kg/m³
				use 3.1 if ≤ 3.2 use 3.3 if > 3.1 ____ kg/m³
	3.4	Modified free-water/cement ratio		____
4	4.1	Relative density of aggregate (SSD)		____ known/assumed
	4.2	Concrete density	Fig 5	____ kg/m³
	4.3	Total aggregate content	C4	____ − ____ − ____ = ____ kg/m³
5	5.1	Grading of fine aggregate	Percentage passing 600 μm sieve	____ %
	5.2	Proportion of fine aggregate	Fig 6	____ %
	5.3	Fine aggregate content	C5	____ × ____ = ____ kg/m³
	5.4	Coarse aggregate content	C5	____ − ____ = ____ kg/m³

Quantities	Cement (kg)	Water (kg or *L*)	Fine aggregate (kg)	Coarse aggregate (kg) 10 mm	20 mm	40 mm
per m³ (to nearest 5 kg)	____	____	____	____	____	____
per trial mix of ____ m³	____	____	____	____	____	____

Items in italics are optional limiting values that may be specified (see Section 7)

1 N/mm² = 1 MN/m² = 1 MPa (see footnote to Section 3).
OPC = ordinary Portland cement; SRPC = sulphate-resisting Portland cement; RHPC = rapid-hardening Portland cement.
Relative density ≡ specific gravity (see footnote to Para 5.4). SSD = based on a saturated surface-dry basis.

Table 2 Approximate compressive strengths (N/mm²) of concrete mixes made with a free-water/cement ratio of 0.5

Type of cement	Type of coarse aggregate	Compressive strengths (N/mm²) Age (days) 3	7	28	91
Ordinary Portland (OPC) or sulphate-resisting Portland (SRPC)	Uncrushed	22	30	42	49
	Crushed	27	36	49	56
Rapid-hardening Portland (RHPC)	Uncrushed	29	37	48	54
	Crushed	34	43	55	61

1 N/mm² = 1 MN/m² = 1 MPa (see footnote on earlier page).

Table 3 Approximate free-water contents (kg/m³) required to give various levels of workability

Slump (mm)		**0-10**	**10-30**	**30-60**	**60-180**
Vebe time(s)		**>12**	**6-12**	**3-6**	**0-3**
Maximum size aggregate (mm)	**Type of aggregate**				
10	Uncrushed	150	180	205	225
	Crushed	180	205	230	250
20	Uncrushed	135	160	180	195
	Crushed	170	190	210	225
40	Uncrushed	115	140	160	175
	Crushed	155	175	190	205

Note: When coarse and fine aggregates of different types are used, the free-water content is estimated by the expression

$$\tfrac{2}{3} W_f + \tfrac{1}{3} W_c$$

where W_f = free-water content appropriate to type of fine aggregate
and W_c = free-water content appropriate to type of coarse aggregate.

5.3 Determination of cement content (Stage 3)

The cement content is determined from calculation C3:

$$\text{Cement content} = \frac{\text{free-water content}}{\text{free-water/cement ratio}} \quad \ldots C3$$

The resulting value should be checked against any maximum or minimum value that may be specified. If the calculated cement content from C3 is below a specified minimum, this minimum value must be adopted and a modified free-water/cement ratio calculated which will be less than that determined in Stage 1. This will result in a concrete that has a mean strength somewhat higher than the target mean strength. Alternatively, the free-water/cement ratio from Stage 1 is used resulting in a higher free-water content and increased workability.

On the other hand, if the design method indicates a cement content that is higher than a specified maximum then it is probable that the specification cannot be met simultaneously on strength and workability requirements with the selected materials. Consideration should then be given to changing the type of cement, the type and maximum size of aggregate or the level of workability of the concrete, or to the use of a water reducing admixture.

5.4 Determination of total aggregate content (Stage 4)

Stage 4 requires an estimate of the density of the fully compacted concrete which is obtained from Figure 5 depending upon the free-water content and the relative density* of the combined aggregate in the saturated surface-dry condition (SSD). If no information is available regarding the relative density of the aggregate an approximation can be made by assuming a value of 2.6 for uncrushed aggregate and 2.7 for crushed aggregate. From this estimated density of the concrete the total aggregate content is determined from calculation C4:

Total aggregate content = $D - C - W$ ...*C4*
(saturated and surface-dry)

where D = the wet density of concrete (kg/m³)
C = the cement content (kg/m³)
W = the free-water content (kg/m³).

*The internationally known term 'relative density' used in this publication is synonymous with 'specific gravity' and is the ratio of the mass of a given volume of substance to the mass of an equal volume of water.

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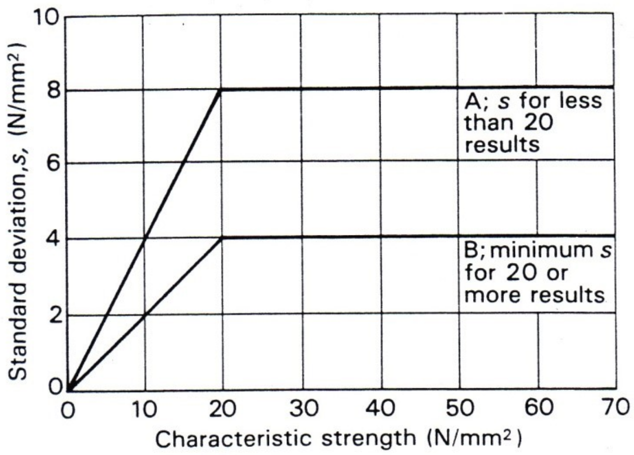

Figure 3 Relationship between standard deviation and characteristic strength

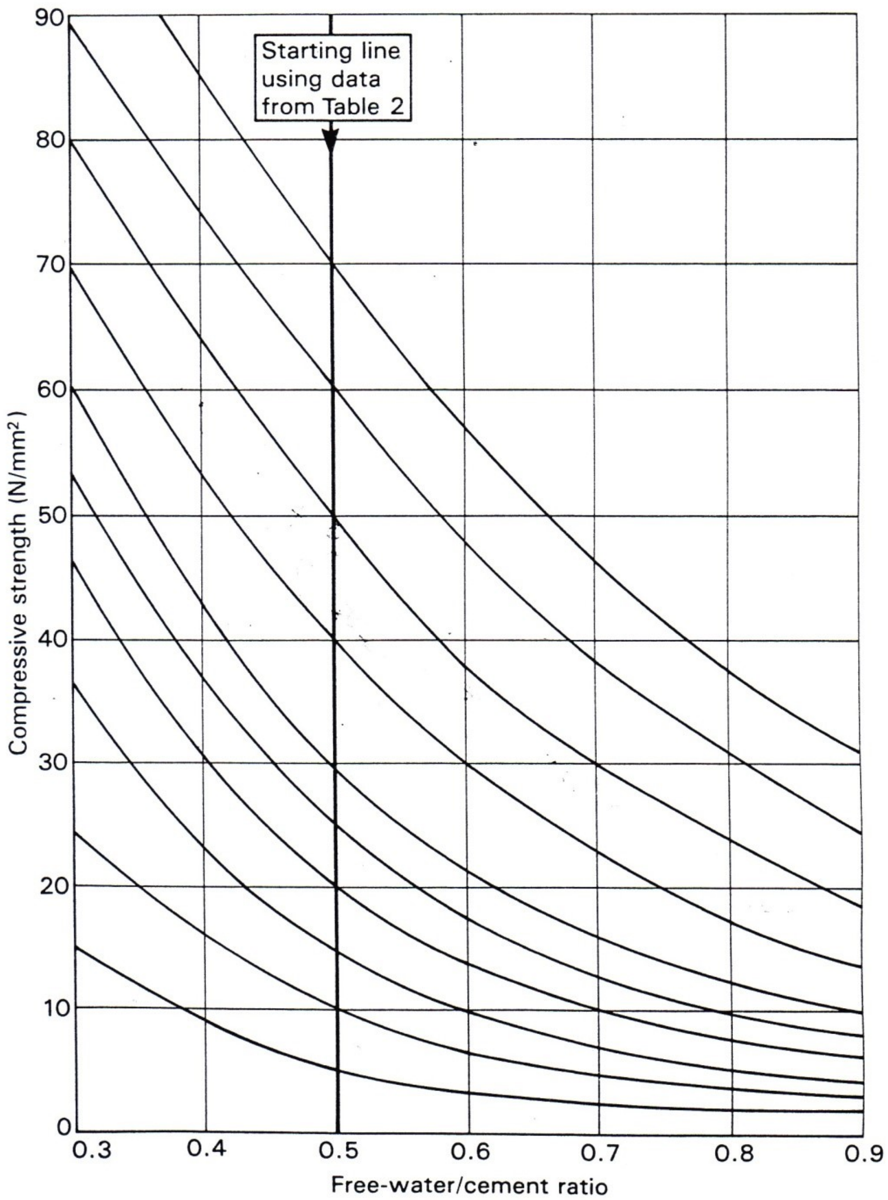

Figure 4 Relationship between compressive strength and free-water/cement ratio

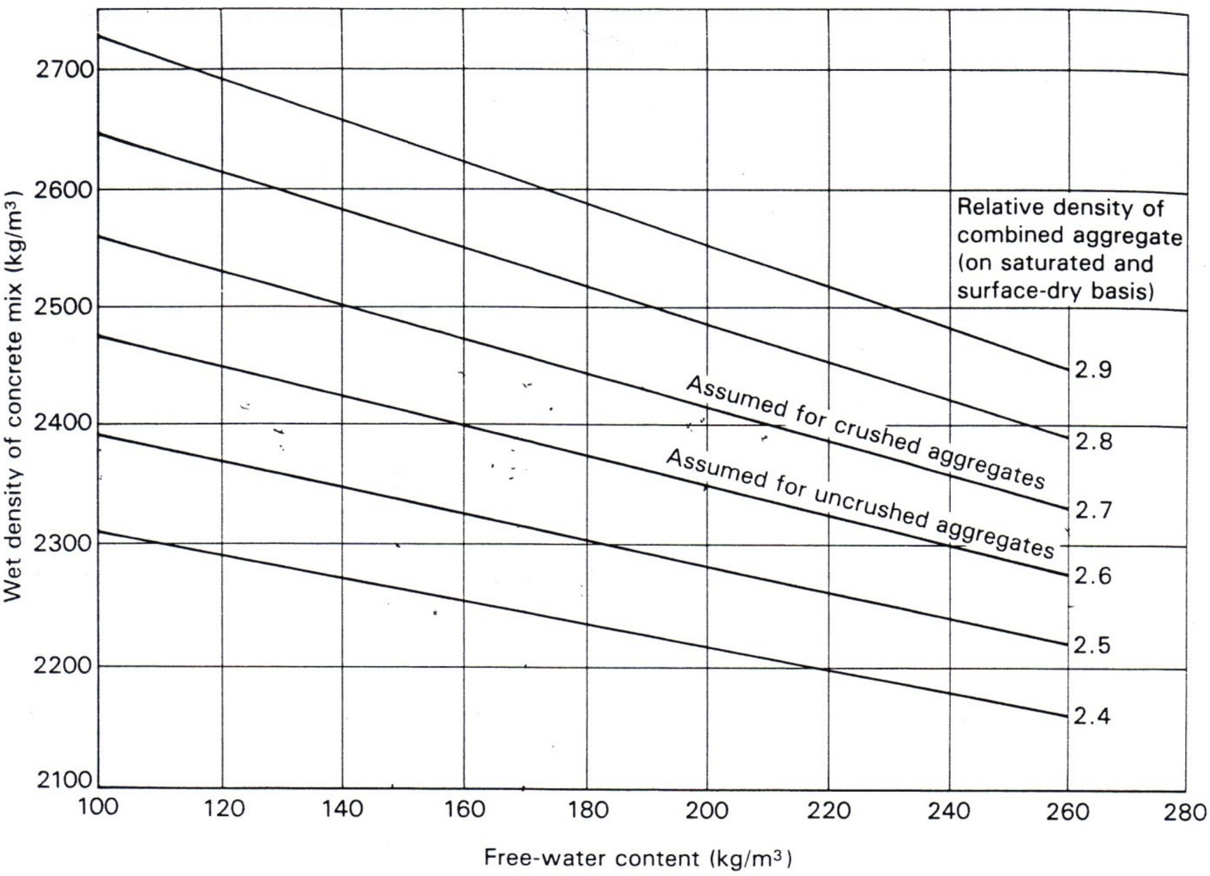

Figure 5 Estimated wet density of fully compacted concrete

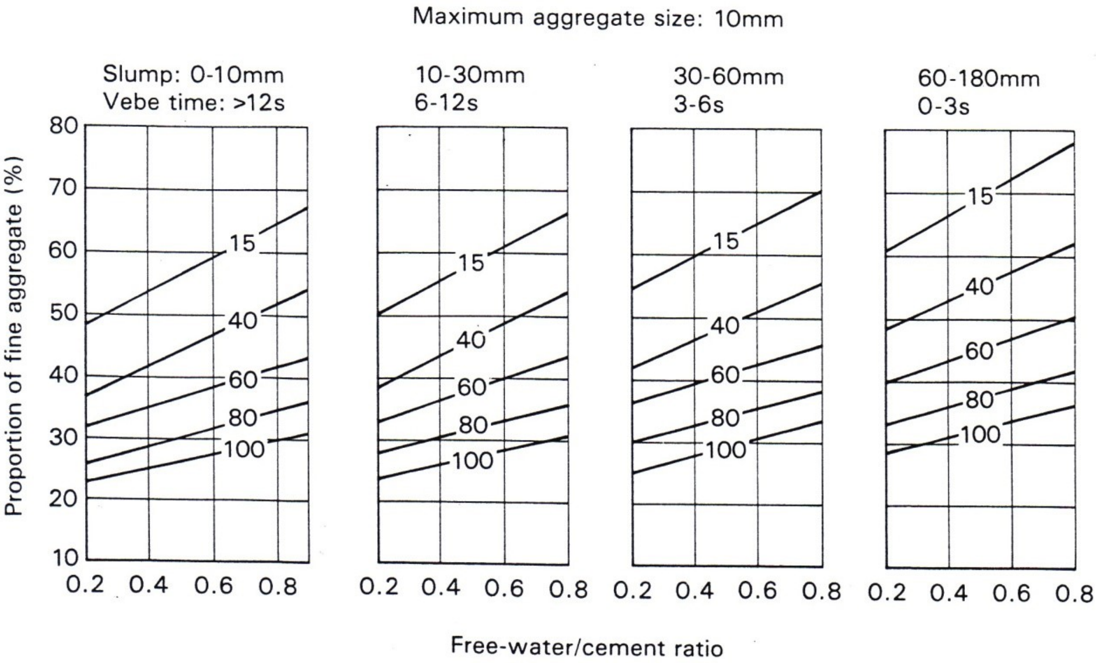

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

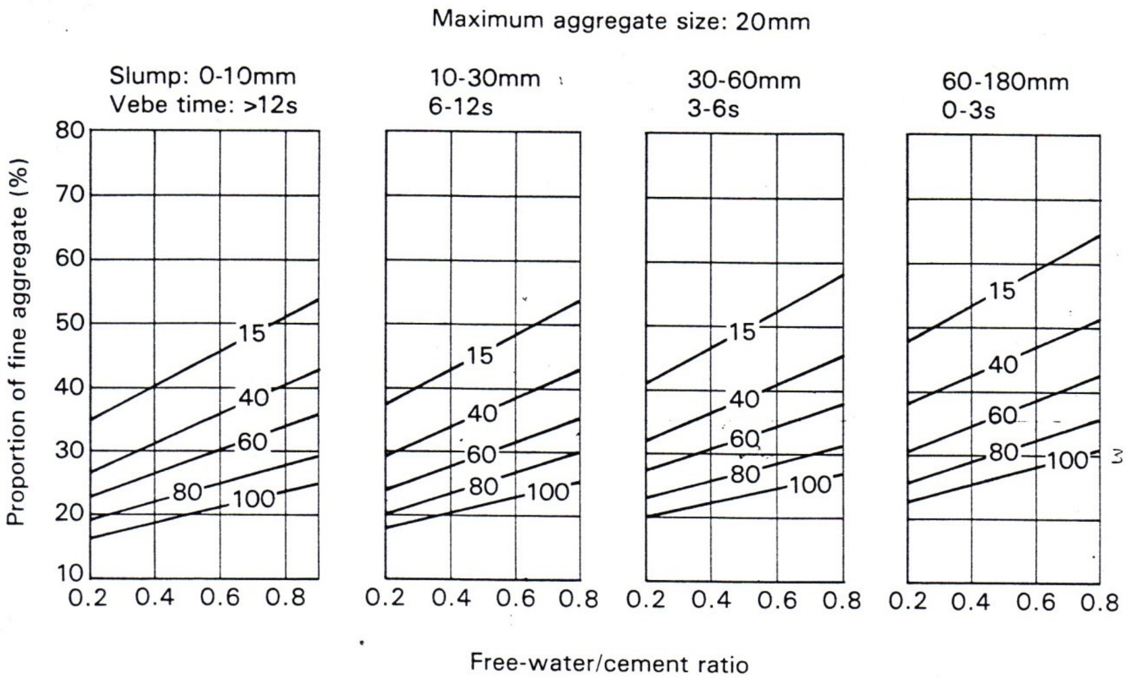

Figure 6 *(continued)*

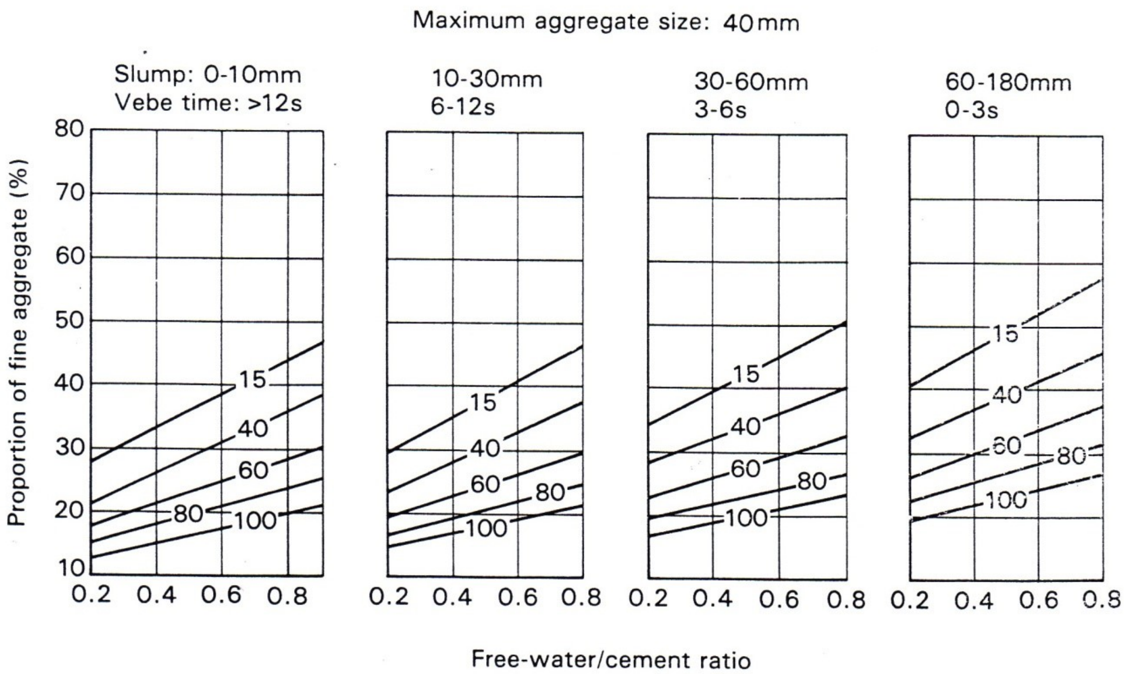

Figure 6 *(continued)*

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